N87-16430

LONG-TERM MODULE TESTING AT WYLE LABORATORIES

JET PROPULSION LABORATORY

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Objectives

- Identify temperature/humidity-bias failure mechanisms in important photovoltaic designs
  - Modules in application experiments
  - R & D modules
  - Commercial modules
- Identify synergisms among the module elements
  - Cells, encapsulants, interconnects
  - Back covers, edge seals

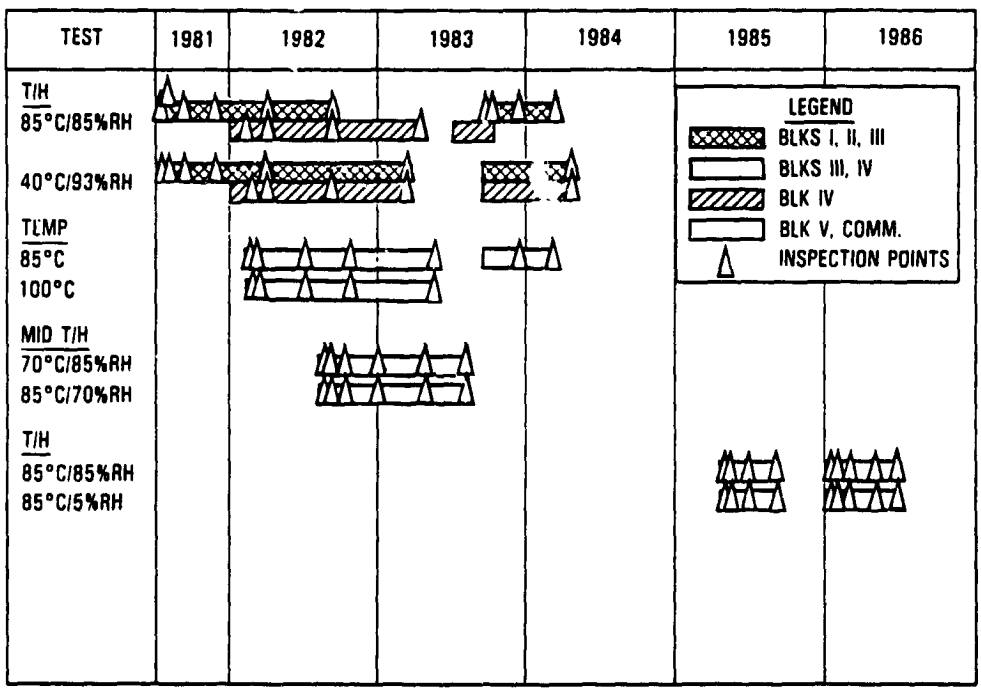
Wyle Laboratories Module Test Set

- Application Experiment Modules
  - Arco Solar - SMUD, Phase 1
  - Solarex - SMUD, Phase 2
  - Mobile Solar - SMUD, Phase 2
  - Solarex - Georgetown
- R & D Modules
  - Westinghouse
- Commercial Modules
  - Tideland Signal
  - Solec

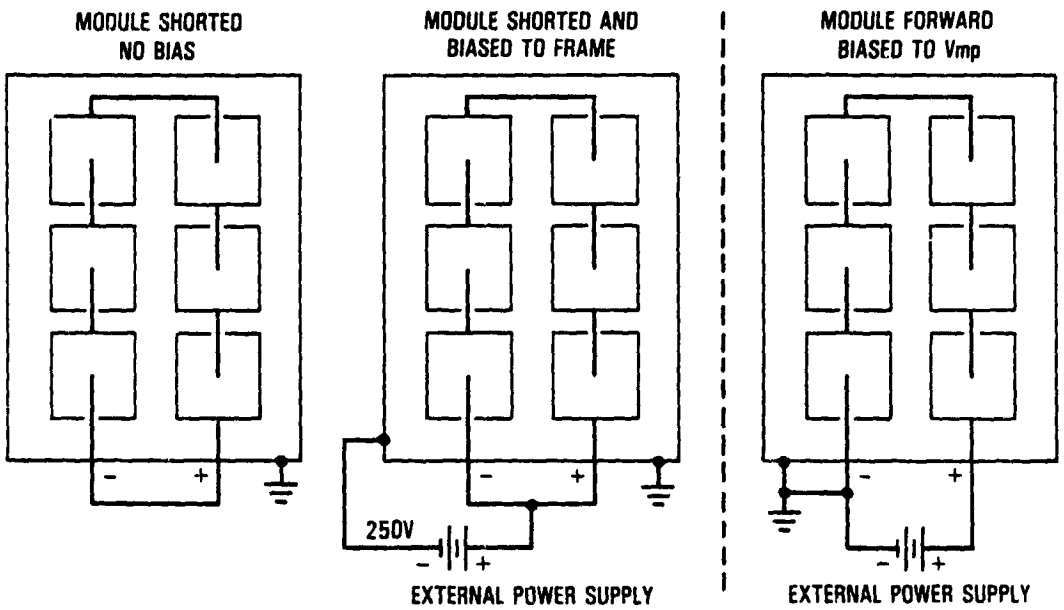
Module Materials

Design Details	Prior Tests	Current Test
Front cover	glass, Tedlar/none	glass
Encapsulants	silicone, PVB, EVA	EVA, APU, silicone
Cell types	CZ (p/n, n/p), semi-Xtl	semi-Xtl, CZ, EFG ribbon, D-web, a-Si
Cell metallization	Ni-Sn, Ti-Pd-Ag, print Ag, Pd-Ni-Sn	Ti-Pd-Cu,print Ag, Ti-Pd-Ag, Ni-Cu-Sn
Back cover	Tedlar, mylar, T-P-T T-Al-T	Tedlar, T-P-T, glass, P-Al-T, T-Al-T, white RTV
Frame	Al, stainless steel	Al, stainless steel
Edge seals	EPDM, RTV, acrylic tape, FRP, PS, butyl, silicone	EPDM, FRP, acrylic tape, mylar tape, none

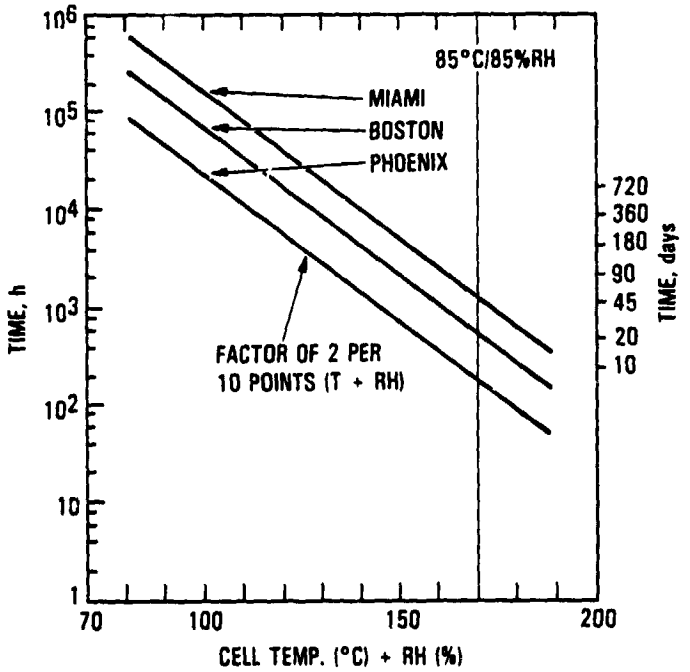
Long-Term Module Testing Schedule at Wyle Laboratories



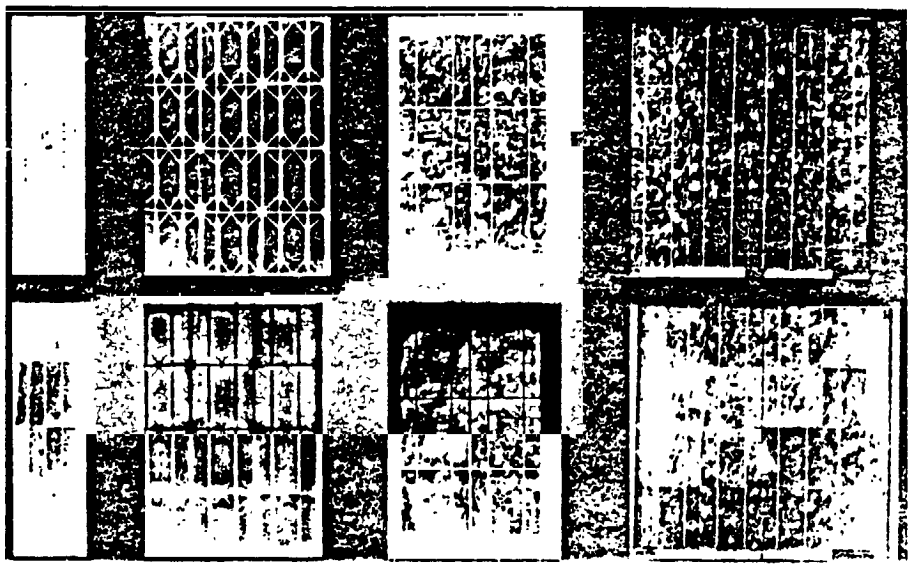
Wyle Laboratories Voltage-Bias Circuits

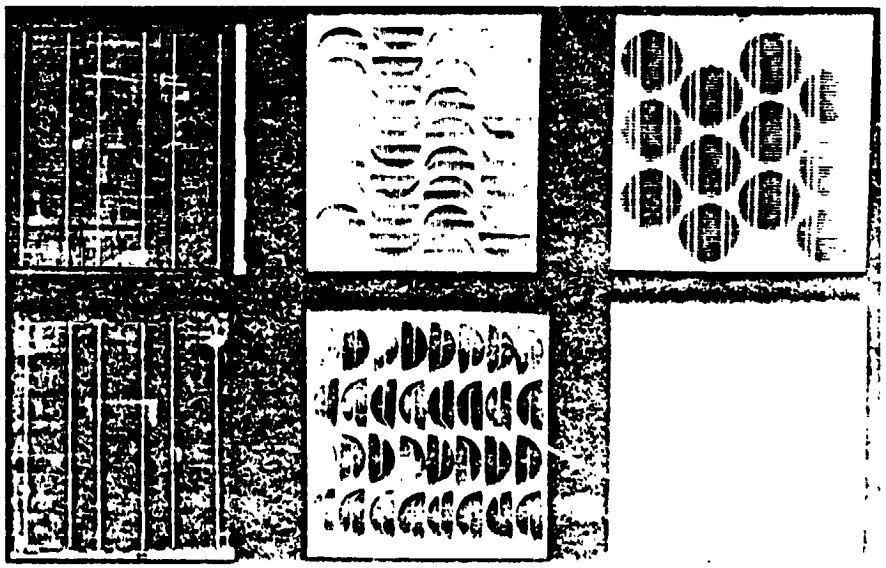


Combined Environment Tests
(Temperature/Humidity Durations Equivalent to a 20-Year Field Exposure)

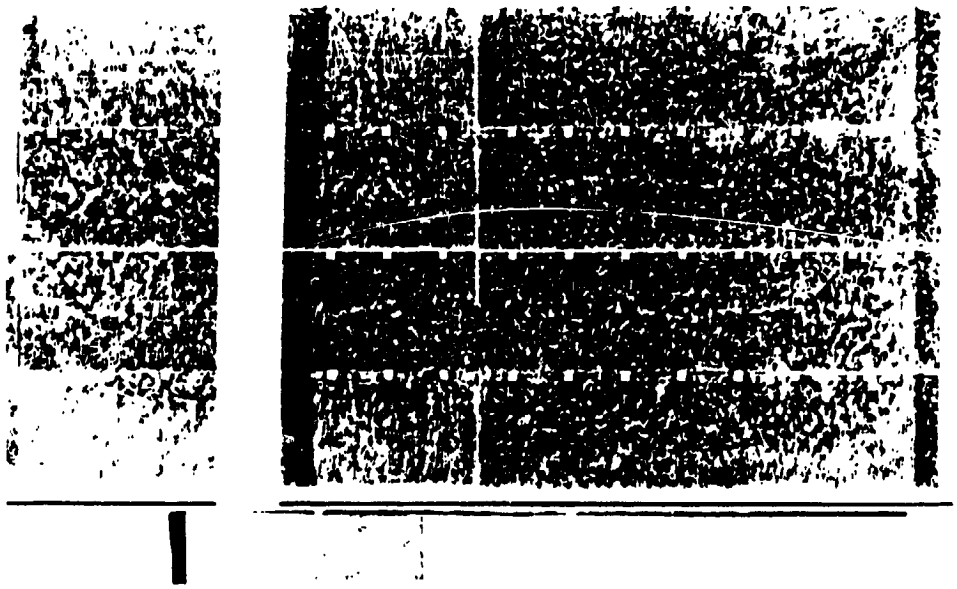


Combined Environment Results: Comparison After 40 Days of Various Module Designs





Electrochemical Degradation of Glass/EVA/Tedlar Module (at Day 40)



Performance Degradation After 40 Days at 85°C/85% RH (Approximately Equivalent to 20 Years in the Field)

Encapsulant	Metallization	P/P_0 Power Loss	
		Transmissivity	Series Resistance
Glass/EVA/Tedlar	Print-Ag	0.98	0.82
	Ti-Pd-Cu	0.96	1.00
	Ti-Pd-Ag	0.95	0.99
Glass/EVA/T-P-T	Print-Ag	0.96	0.91
Glass/EVA/Foil	Ni-Cu-Sn	0.99	0.99
Glass/APU/Glass	Print-Ag	0.97	0.99
Glass/Silicone	Ti-Pd-Ag	0.99	0.97
Strawman 20-year goal for total degradation in all environments		0.96	0.96

Conclusions

- A variety of present module types are consistent with 20-year life with respect to typical temperature/humidity site stress
- Degradation mechanisms identified include:
  - Discoloration of encapsulants
  - Electrochemical corrosion of cell metallization
  - Material diffusion from edge seals
  - Delamination (foil), and embrittlement of back covers
- Important to have voltage-bias in qualification tests
- Important to include both temperature/humidity and temperature-only test for identifying degradation mechanisms